M4476

Analyses of Brain Function and Dysfunction

Analyse der Gehirnfunktion und Dysfunktion

Coordinator (responsible lecturer) Prof. Dr. C. R. Rose (rose@hhu.de)			**Status:** 12.09.2023
Lecturers Rose, Kafitz, Willbold, Hoyer, Nagel-Steger, Tamgüney			**Semester:** 1.- 2.
Contact and organization Joel Nelson (Joel.Nelson@uni-duesseldorf.de)			**Mode:** compulsory elective
Workload 420 h	**Credit points** 14 CP	**Contact time** 225 h	**Self-study** 195 h
Course components Practical course: 18 SWS Lectures/Workshop: 2 SWS Seminar: 1 SWS	**Frequency** Each winter semester	**Group size** 18	**Duration** 1 semester

Intended Learning Outcomes

The students are able to explain the basic structural properties of proteins and their implications in protein misfolding, protein aggregation and neurodegeneration. They can explain and apply biochemical and biophysical methods for characterization of proteins and their (mis)folding and aggregation. Students can handle basic laboratory instruments independently and appropriately. They document their results in a protocol and interpret them in relation to the scientific literature.

The students are able to describe and apply the fundamental concepts and techniques of fluorescence-based immunohistochemistry. They can use these concepts for the identification of various cell types and brain structures and make judgments regarding physiological and development-related questions. Students can use advanced techniques in light and fluorescence microscopy and adequately develop and evaluate the resulting documentation. They will learn to employ state of the art image analyses tools. They will know how to study basic physiological properties of brain cells using different techniques such as dynamic ion imaging and properly record, store, analyze, and illustrate the experimental data obtained with the specific techniques presented.

Students will learn to critically evaluate and interpret their experimental findings. They are able to give an informative overview of scientific questions, experimental design, results and interpretation of the performed experiments both in oral and in written form.

Forms of teaching

Lecture (face to face and/or virtual), Workshop (face to face training and/or virtual), Practical course (hands on and virtual), Seminar (face to face and/or virtual)

Content

(*Physical Biology will cover 2 weeks; Neurobiology will cover 4 weeks of the course*)

Lecture "Protein aggregation in neurodegenerative diseases"

Protein structure. Thermodynamics of protein folding. Protein misfolding and aggregation. Spectroscopy: Fluorescence and circular dichroism. The prion protein and prion diseases as an example for protein misfolding and seeding in neurodegeneration. Prion-like proteins in neurodegenerative diseases. Fundamentals of Alzheimer's disease and Parkinson's disease. Mouse models of neurodegenerative diseases. Drug development for treatment of neurodegenerative diseases.

Lecture "Analysis of Brain Function and Dysfunction"

Development of selected brain regions (cortex, hippocampus, cerebellum). Maturation and function of neurons and glial cells in vertebrate brains and synapse formation. Molecular and cellular basis of neuronal and glial cell function, properties of glial cells and neuron-glia interaction. Basic concepts of extra- and intracellular ion homeostasis, extra- and intracellular ion signaling. Excitotoxicity and role of ion dysbalance in brain pathology and in brain ischemia. Glial cells as central elements in brain pathology.

Basics of light microscopy: optics and lenses, structure of a microscope, optical path, aberrations, types of microscopes. Basics of fluorescence microscopy and immunohistochemistry. Fluorochromes, illumination, artefacts. Cell-type-specific labeling of neural cells with diagnostic antibodies.

Workshop "Fluorescence microscopy and Imaging"

Basics of dynamic fluorescence imaging: Wide-field, confocal, multiphoton microscopy and FLIM. Superresolution microscopy: STED, SIM and PALM/STORM.

Imaging with ion-sensitive fluorescent dyes and genetically-expressed sensors, ion-sensitive microelectrodes. General lab work, use of eLab-FTW, statistical analysis, presentation of data.

Practical course:

Physikalische Biologie: Seeding assays to elucidate pathological protein aggregation

Protein aggregation assays: Sample preparation of aggregation-prone proteins, fluorescence spectroscopy, CD spectroscopy, SDS-PAGE, design, execution and evaluation of seeding assays.

Cellular seeding assays: Fundamentals of cell culture techniques, light and fluorescence microscopy, imaging, data acquisition, and analysis.

Neurobiology: Immunohistochemistry and Dynamic Cellular Imaging

Immunohistochemistry: Primary and secondary immunofluorescence, identification of neural cell types, determination of the maturation stages of glial cells and neurons, marking of functionally relevant membrane structures in neurons and glial cells.

Fluorescence microscopy: Components of a light microscope, epifluorescence microscopy, confocal laser microscopy, camera-assisted documentation, image processing.

Cellular Imaging: Dynamic life imaging of intracellular ion signals under physiological and pathophysiological conditions (e. g. calcium imaging, sodium imaging and/or imaging of pH dynamics). Measurement of extracellular ion changes using ion-selective microelectrodes.

Analysis: Data analysis of given data sets/own data sets, statistics, arrangement of data in figures and presentation.

Recommended reading, lecture notes:

Imaging in Neuroscience and Development: A Laboratory Manual. Cold Spring Harbor Laboratory Press

Development of the Nervous System. Sanes, Reh & Harris, Elsevier 2012.

Additional scripts and other documents will be available electronically through ILIAS.

Prerequisites

Formal: Successful completion of module 1; Proficiency in English level B2 of Common European Framework of Reference for Languages (CEFR)

With regards to content: Knowledge of cell biology, chemistry, physics, mathematics as well as basic knowledge of neurobiology required.

Examination types

Cumulative examination:

(1) Written examination about the contents of the module including lectures, workshops and

practical protocols and strategies (70% of overall mark),
(2) Physikalische Biologie (10%): Experiment protocol
(3) Neurobiology: Description of analyses by pictures and notes, performance of experiments and analysis (10% of overall mark)
(4) Neurobiology: Presentation: drafting of project, graphical description of project, presentation and discussion (10% of overall mark)

Requirements for the award of credit points for this course
Regular and active attendance at the practical course and virtual sessions.
Successful completion of the practical courses.
Oral presentation in a seminar with an accompanying written hand out.
The final grade is calculated from the mark of the written exam (weigh 70% of final grade) and the description of analyses, performance of experiments and the presentation (weigh 30%).

Relevant for following study programs/major
M.Sc. Biologie
M.Sc. Translational Neuroscience
Major:
(X) Biomedicine & Cell Biology
(.) Evolution & Biodiversity
(.) Plant Sciences - Climate protection & Food security
(.) Artificial Intelligence & Data Science
(.) Pathogens & Infection Biology
(.) Synthetic Biology & Biotechnology

Compatibility with other curricula
M. Sc. Molecular Biomedicine, M.Sc. Translational Neurosciences

Significance of the mark for the overall grade
The mark given will contribute to the final grade in proper relation to its credits.
M.Sc. Biologie 14/72 CP (2-years program)

Course language
☐ German
☒ English
☐ German and English
☐ German, English on demand

Additional information
Enrolling into the module is granted by the central study office of the Department of Biology.
http://www.biologie.hhu.de/en/studies-in-biology/students-info/central-allocation-of-modules.html